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Russian Translation

The Structure of Thin Iron Films Deposited by Evaporation in a Vacuum

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The structure of thin ferromagnetic films must be known when studying their magnetic properties. Consequently, we tried to determine the structure of thin iron films which were studied from the point of view of their magnetic properties. The iron films were prepared by evaporation on a vitreous ladle in a high vacuum ($p < 10^{-4}$ mm Hg). Strips of pure iron were used for the evaporation, which were first heated to a temperature of about 1470° C by passage of an electric current through them. The iron strips were heated for approximately two hours prior to the evaporation in order to eliminate impurities in their surfaces. Only afterward did preparation of the films begin. The prepared films were kept in the vacuum apparatus for some time althoug their temperature was not equivalent to room temperature.

The specimens, thus prepared, were investigated on an electronic diffractograph (Steel Research Inst.). Two specimens were studied for which the thicknesses were determined by using interference [1]: (I) δ = 3450 Å , (II) δ = 2340 Å . The electron diffraction occurred almost for tangential incidence of the electron beam onto the specimen surface for two wavelengths (λ_1 = 0.0554 Å , λ_2 = 0.0517 Å

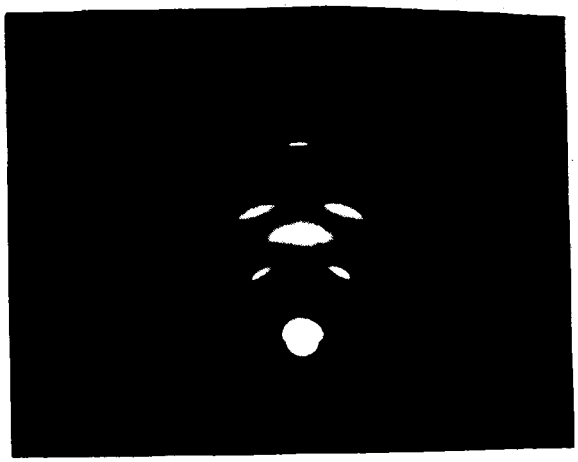

Figure 1. Electronogram of a thin iron film

The films show a three-dimensionally centered cubical lattice and their characteristics are identical for both specimens (fig. 1). The lattice constant, computed

from the diameters of the diffraction circles is $a = 2.88$ Å, which agrees, within the limits of experimental error, with the value of the lattice constant for compact iron, $a = 2.866$ Å. The texture is seen clearly expressed on the diffraction picture. As seen from the following, both specimens have a fibrous texture with the texture axis [111] perpendicular to the film surface. This means that the crystals in the film are oriented so that their crystalline boundaries [111] are perpendicular to the film surface and they are oriented randomly therein. This verifies the fact that the rotation of the specimen around the texture axis does not alter the interference picture (the diffraction picture in a specific position and in a position rotated through 90°). Shown on figure 2 are the diffraction circles of the separate interferences with the corresponding locations of the condensation. Because the film is planar the condensation locations lie on hyperbolas.

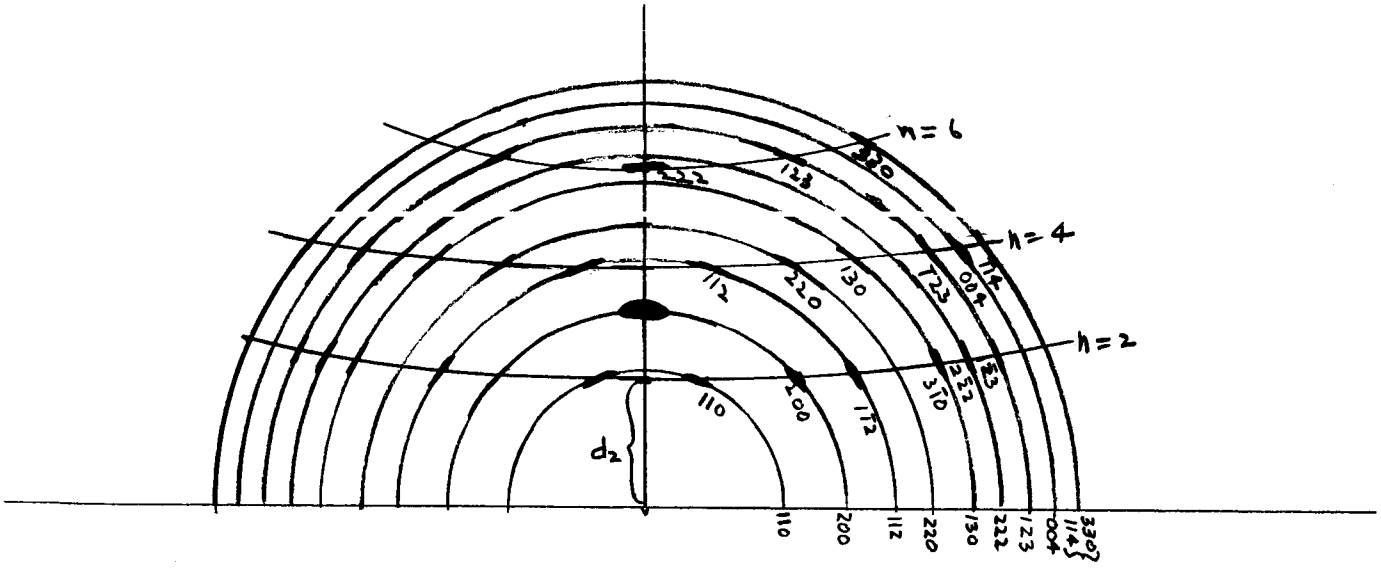

Figure 2. Diffraction circles and locations of condensation on hyperbolic horizontals (schematic)

The reflection indexes hkl of the horizontals and the indexes of the texture axes [uvw] satisfy the condition:

$$hu + kv + lw = n$$

which is, for the [111] texture axis:

$$h + k + l = n \qquad (n = 2,4,6,\ldots)$$

because the period of identity $t_{[111]}$ in the direction of the diagonals of the three-dimensionally centered cubical lattice equals half of it; $t_{[111]} = 2.482$ Å for iron. We have for $t_{[uvw]}$

$$t_{[uvw]} = \frac{n\lambda r}{d_n}$$

where λ is the wavelength, r is the distance of the specimen from the photofilm and d_n is the distance from the vertex of the horizontal to the middle of the film. The relation cited for $t_{[uvw]}$ occurs in the case of perpendicular incidence of the electron beam on the texture axis and for $d_n \ll r$. The values of d_n were measured on the film as: $d_2 = 9.3$ mm, $d_4 = 18.5$ mm, $d_6 = 28.0$ mm. The values of $t_{[uvw]}$ for $\lambda = 0.0554$ Å and $r = 417.5$ mm are:

$$2.48 \; ; \quad 2.49 \; ; \quad 2.47 \text{ Å}$$

which are in good agreement with the value calculated for iron of* $t_{[111]} = 2.482$ Å.

We have not yet encountered such a result in the literature; that the iron crystals in a thin film, obtained by evaporation in a high vacuum are oriented parallel to the film backing in the (111) plane. Glocker and Kaupp [2] disclosed, when investigating films superposed electrolytically on copper or iron, that a fibrous texture forms with the [111] texture axis for the iron, which is parallel to the current line direction, if the iron is obtained from an aqueous solution of $FeCl_2$; the texture axis changes to [112] for $CaCl_2$ impurities in this electrolyte. Elenbaas [3], who investigated the magnetic properties of thin films of iron and nickel superposed electrolytically on copper, detected, just as in our case, a fibrous texture with the [111] texture axis for iron. He also disclosed that this texture does not exist for films thinner than 3.6 μ and that

* The condensation location, at the geometric locations of the horizontal of the 200 diffraction circle, does not match the system of curves on the film. This condensation location probably forms by reflection of the primary electron beam from the backing of the evaporated film.

it is expressed more explicitly for thicker films the greater the current density during electrolysis. Finally, there results from the paper of Beeck [4], that the same crystal orientation occurs for thin films of iron evaporated in a gas atmosphere (p $\sim$ 1 mm Hg) as we observed during the evaporation in a high vacuum.

Techn. Phys. Inst.
Steel Research Inst.

Jan. 1955

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3. W. ELENBAAS: Zs. f. Phys., 76 (1932), 829

4. O. BEECK: Rev. Mod. Phys., 17 (1945), 61